APPENDIX J MONITORING

This appendix is intended to provide general guidelines for developing streambank protection and stream restoration monitoring plans. Monitoring is defined as the collection and assessment of repeated observations or measurements over time to evaluate the effectiveness of management actions or projects. This appendix provides a framework for monitoring activities that integrates riparian and fluvial processes with assessments of the physical integrity and performance of streambank protection and stream restoration projects.

Reasons to Monitor

Monitoring allows property owners, scientists, and regulators to measure the effectiveness of projects under a range of changing environmental factors, including flooding or drought, channel shifts and erosion, and biologic factors such as beaver activity or the effects of animal grazing. In addition, monitoring helps identify maintenance and project repair needs, measure effectiveness through time and provide information on ways to improve and refine techniques. Monitoring can also be used to evaluate watershed restoration strategy—not limited to a single project.

This appendix will introduce and discuss the key components of monitoring streambank protection and stream restoration projects. Additional and specific information on monitoring streambank protection and stream restoration projects can be found in the *Techniques* chapters of the *Integrated Streambank Protection and Stream Habitat Restoration Guidelines*, respectively, where each technique description contains a discussion on monitoring considerations.

Monitoring begins during project planning as existing conditions are assessed, data collected and project alternatives developed. Monitoring is an essential component of project design and evaluation required not only to determine success of the restoration project, but critical to restoration program accountability. The data collected for monitoring will vary greatly among projects depending on the size, scope and type of activity and goals of the restoration effort.

Restoration monitoring should be guided by predetermined criteria and checklists and allow for the recording of results in regular monitoring reports. The technical analysis in a monitoring report should identify and discuss options to address deficiencies. Monitoring plans should be conceived during the planning phase when the goals and performance criteria are developed for the restoration effort. Baseline information collected before project implementation forms the data set on pre-restoration conditions against which success of the restoration effort can be evaluated.

During the design process, the relationship between project objectives, restoration measures, evaluation and success criteria, contingency measures, and evaluation

techniques should be fully explored and defined. Clearly defining project objectives is central to post-project evaluation. Evaluation success criteria should be developed based on historical information and data gathered from the project site and applicable reference site using proposed evaluation techniques. In some cases, one criterion may serve as an indicator for multiple objectives (Kondolf and Micheli 1995).

Statement of Monitoring Objectives

Monitoring should not be initiated without a reason. That reason should be clearly stated prior to the collection of data. Monitoring can be a very powerful tool to evaluate project success and impacts, watershed restoration strategy success, to compare the effectiveness of various techniques, and to determine the need for maintenance activities and repairs. However, monitoring without a definable goal is a waste of time, effort, and money

Baseline Data

Monitoring cannot be conducted unless, prior to restoration, baseline data is collected. This data is used to provide needed information, document chronological and other aspects of restoration succession, and provide lessons learned to be used in similar project types. Development of a monitoring plan should include specifying and assembling baseline data that will be referenced in subsequent monitoring. Project success can only be evaluated in reference to a baseline condition. It may need to include historical information and/or control sites. Baseline data should correspond in format and detail to all subsequent data collected in order to measure success or impacts on both qualitative and quantitative levels. It is important to consider the timing of baseline conditions relative to annual hydrologic cycles and fish life cycles. Baseline-data collection and subsequent monitoring should be conducted at the same time of the year relative to fish life cycles and hydrologic conditions (Kondolf 1995).

Baseline-data collection may include, but should not be limited to,

- establishment of permanent benchmarks (located away from areas of potential bank erosion);
- as-built survey to document the project's configuration relative to permanent benchmarks;
- summary of site hydrology (including location of the nearest gauging station) and values for critical flows that will be used to initiate monitoring events;
- documentation of aerial photography, summary of erosion history and any other geomorphic data pertinent to project location and design;
- documentation of pre-project site and reach data pertaining to fish use, the riparian corridor, floodplain function and overall habitat condition; and

- documentation of any other conditions related to project objectives.

Additionally, baseline data should be collected using the methods established in the monitoring protocol. It is crucial that qualitative and quantitative baseline-data collection be thorough and appropriate to provide a sound foundation for subsequent data collection and monitoring (Kondolf 1995).

Types of Monitoring

The following seven types of monitoring are not mutually exclusive and often the distinction between them is determined more by the purpose of monitoring than by the type and intensity of measurements (MacDonald et al. 1991).

1. Trend monitoring: Use of the term "trend" implies that measurements will be made at regular, well-spaced time intervals in order to determine the long-term trend in a particular parameter.

2. Baseline monitoring: Baseline monitoring is used to characterize existing conditions, and to establish a database for planning or future comparisons. The intent of baseline monitoring is to capture much of the temporal variability of the parameters of interest, but there is no explicit end point at which continued baseline monitoring becomes trend monitoring. This type of monitoring is also called "inventory" or "assessment" monitoring.

3. Implementation monitoring: This type of monitoring assesses whether activities were carried out as planned. The most common use of implementation monitoring is to determine whether Best Management Practices (BMPs) were implemented as specified. Typically this is carried out as an field review and does not involve any measurements.

4. Effectiveness monitoring: Effectiveness monitoring is used to evaluate whether the specified activity had the desired effect.

5. Project monitoring: This type of monitoring assesses the impact of a particular project. Often this type of monitoring is done by comparing data taken upstream and downstream of the project, although in some cases the comparison may be on a before and after basis. Project monitoring may be considered a subset of effectiveness monitoring.

6. Validation monitoring: Validation monitoring is used to validate the quality of data output from prediction models and answer the question; Were the objectives of the project met because of the planned habitat changes?

7. Compliance monitoring: This is the monitoring used to determine whether specified criteria are being met. The criteria can be numerical or descriptive.

Usually the regulations associated with individual criterion specify the location, frequency, and method of measurement.

These types of monitoring illustrate two important points:

- Confusing means with the ends. Saying that management is successful because an action was taken (e.g. a site was burned, a fence was built). This is mixing up implementation and effectiveness monitoring.

- The difference between monitoring and research. Monitoring uses good sampling design within the constraints of populations and sites to assess status and trends. Research evaluates cause and effect with a rigorous experimental design that usually includes natural or purposeful manipulations, with two or more treatments that are independently applied and replicated, and rigorously testing hypotheses. Monitoring may suggest cause and effect, but does not evaluate such relationships with the same degree of rigor (TNC 1999).

Monitoring Plan Development

The following list can serve as a checklist of topics and details that should be included in any monitoring plan. See chapter 6b of "Stream Corridor Restoration" by the Federal Interagency Stream Restoration Working Group (http://www.usda.gov/stream_restoration/newgra.html) for details on how to develop a monitoring plan based on this outline.

A. Planning

Step 1: Define the restoration, vision, goals, and objectives

Step 2: Develop the conceptual model

Step 3: Choose performance criteria

- Link performance to goals
- Develop the criteria
- Identify reference sites

Step 4: Choose monitoring parameters and methods

- Choose efficient monitoring parameters
- Review watershed activities
- Choose methods for sampling design, sampling, and sample handling/processing
- Conduct sociological surveys
- Rely on instream organisms for evidence of project success
- Minimize the necessary measurements of performance
- Incorporate supplemental parameters

Step 5: Estimate cost

- Cost for developing the monitoring plan itself
- Quality assurance
- Data management

- Field sampling program
- Laboratory sample analysis
- Data analysis and interpretation
- Report preparation
- Presentation of results

Step 6: Categorize the types of data

Step 7: Determine the level of effort and duration of monitoring

- Incorporate landscape ecology
- Determine timing, frequency, and duration of sampling
- Develop statistical framework
- Choose the sampling level

B. Implementing and Managing

- Vision for the life of the monitoring plan
- Clearly define roles and responsibilities
- Enact quality assurance procedures
- Interpret the results
- Manage the data
- Provide for contracts

C. Responding to the Monitoring Results

- No action
- Maintenance
- Adding, abandoning, or decommissioning plan elements
- Modification of project goals
- Adaptive management
- Documentation and reporting
- Dissemination of results

Table A10.1 provides some examples of restoration objectives linked to specific performance evaluation tools and measures (Kondolf and Micheli 1995).

General Objectives	Evaluation Tools and Criteria
Improve channel capacity and stability	Channel cross sections
	Flood stage surveys
	Width-to-depth ratio
	Rates of bank or bed erosion
	Longitudinal profile
	Aerial photography interpretation
Improve aquatic habitat	Water depths
	Water velocities
	Percent overhang, cover, shading
	Pool/riffle composition
	Stream temperature
	Bed material composition

	Population assessments for fish, invertebrates, macrophytes
	Fish passage barrier assessment
	Large woody debris survey
Improve riparian habitat	Percent vegetative cover
	Species density
	Size distribution
	Age class distribution
	Plantings survival
	Reproductive vigor
	Bird and wildlife use
	Aerial photography
Improve water quality	Temperature
	Ph
	Dissolved oxygen
	Conductivity
	Nitrogen
	Phosphorous
	Herbicides/pesticides
	Turbidity/opacity
	Suspended/floating matter
	Trash loading
	Odor
Recreation and community involvement	Visual resource improvement based on landscape control point surveys
	Recreational use surveys
	Community participation in management

The following references provide details on how to use each of the tools identified in the above table:

Bain, Mark and Nathalie Stevenson, editors. 1999. Aquatic habitat assessment: common methods. American Fisheries Society, Bethesda, MD.Harrelson, Cheryl, C.L. Rawlins, and J. Potyondy. 1994. Stream channel reference sites: an illustrated guide to field technique. Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61p.

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Kaufmann, Phillip and E. G. Robinson. 1994. Section 6 *in* Klemm, Donald and James Lazorchak, editors. Environmental monitoring and assessment program: surface waters and Region 3 regional environmental monitoring and assessment program. Environmental Monitoring Systems Laboratory, Environmental Protection Agency, Cincinnati, OH.

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Kondolf, G. M. and E. R Micheli. 1995. Evaluating Stream Restoration Projects. Environmental Management 19(1): 1-15.

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The Nature Conservancy. 1999. Vegetation monitoring in a management context. A workshop coordinated by The Nature Conservancy. Indiana Dunes National Lakeshore, IL.

Additional Reading

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Roni, Philip, Liermann, Martin, and Ashley Steel. Monitoring and evaluating responses of salmonids and other fishes to instream restoration. IN: Montgomery, D.R., Bolton, S., and Booth, D.B. (editors). Restoration of Puget Sound Rivers, University of Washington Press, in preparation

USDA – NRCS. 1999. Stream corridor inventory and assessment techniques. Watershed Science Institute Technical Report. 30p